

Historic, archived document

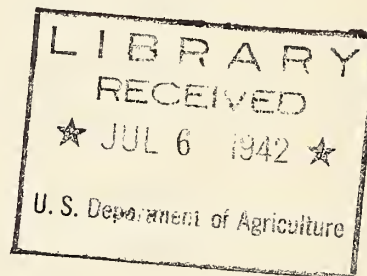
Do not assume content reflects current
scientific knowledge, policies, or practices.

1.982
A2Ag8
no. 121
Reserve

ACE-121

UNITED STATES DEPARTMENT OF AGRICULTURE
Bureau of Agricultural Chemistry and Engineering

CORN, ITS PRODUCTS, AND USES



U.S. Bureau of Agriculture Prepared by
Northern Regional Research Laboratory
Peoria, Illinois

October 1941

CONTENTS

Origin	1
Types	1
Hybrid corn	2
Advantages of different hybrids	3
Commercial classification	4
Structure of kernel	6
Composition	6
Moisture in corn	10
Production	10
Relative value as a farm crop	10
Present uses	15
Seed	15
Feed	20
Food	21
Industrial uses	25
Corn utilization research	31

CORN, ITS PRODUCTS, AND USES

Prepared by

Northern Regional Research Laboratory
Bureau of Agricultural Chemistry and Engineering
United States Department of Agriculture

Peoria, Illinois

ORIGIN 1/

On November 5, 1492, two Spaniards whom Christopher Columbus had delegated to explore the interior of Cuba returned with a report of "a sort of grain they call maiz which was well tasted, bak'd, dry'd, and made into flour." And so was introduced to the white man a plant which has since become, from the standpoint of total production, the second most important food plant in the world.

Very little or nothing is known of the botanical origin of corn, or the evolution of earlier forms to the main types known today. No evidence has been found that prior to the discovery of America, corn had been grown anywhere in the world except in the Western Hemisphere. In that part of the world it had attained great importance, and, according to archeologists, was the basis of the ancient civilizations of Peru, Central America, and Mexico.

Corn or maize is a grass, though a most unusual one. Within the grass family (Gramineae), maize is assigned to the tribe Maydeae, composed of eight genera, five of which are Oriental and three American. The species Zea mays L. is the one comprising all the cultivated varieties of corn.

TYPES

The cultivated varieties of corn, Zea mays, are of five general types, as follows: Pop corn, Z. everta; flint corn, Z. indurata; dent corn, Z. indentata; flour corn, Z. amylacea, sometimes called "soft"; and sweet corn, Z. saccharata. Another type sometimes mentioned is pod maize, Z. tunicata.

1/ The Origin of Indian Corn and its Relatives. By P. C. Manglesdorf and R. G. Reeves. Tex. Agr. Expt. Sta. Bul. 574. 1939. Corn Improvement. By Merle T. Jenkins. U.S. Dept. Agr. Yearbook, pp. 455-522. 1936.

The pop type of maize is characterized by its ability to pop when subjected to high temperatures. It occurs in two general styles of kernel, the one rice-shaped with a pointed end and the other flat with rounded end. Both are small and hard. The flint type is characterized by its hardness of kernel with a rounded top and a small area of soft endosperm around the embryo completely surrounded by corneous endosperm. The dent type is characterized by wedged-shaped kernels with an indented top and the soft endosperm extending to the top with corneous material confined mainly to the sides of the kernel. In the flour or "soft" maize type the endosperm is entirely of a soft starchy character. In shape and outward appearance it is similar to flint corn but varies in size from not much larger than grains of pop maize to nearly an inch long. Sweet maize is that type in which the endosperm is translucent and horny in appearance, the starch being partially replaced by sugar. In the pod type of maize each grain is covered with a husk, in addition to the ear itself being so covered. Its kernels vary greatly in size and shape. This type of corn is rarely grown.

Only the dent and flint types of corn are used commercially; therefore, only these two types will be considered further in this paper. The dent type is the most usual type grown in the United States, constituting more than 90 percent of the production. In Argentina, the world's second largest producer of corn, the reverse is the case, with flint corn representing approximately 99 percent of the total production. In the United States the production of flint corn is confined to northern Pennsylvania, New York, the New England States, California, and the western and northern rim of the Corn Belt.

HYBRID CORN

Hybrid corn is the first major improvement the white man has made in corn since it was taken over from the early American Indian. The Indian had already developed all the main types. In the four and one-half centuries of cultivation by the white man, about the only important changes that have been accomplished are the selection of the present-day dent varieties and the development and use of hybrids for seed.

According to Doctor Merle T. Jenkins of the Bureau of Plant Industry, ^{2/} the history of artificial crossing in corn goes back at least 60 years. W. J. Beal of the Michigan Agricultural Experiment Station is reported as the first to produce crosses in corn purely for their increased vigor and yield. Not until after 1930 did the production of hybrid seed corn assume any commercial importance. It has been estimated that in 1940 one-half of the corn acreage in the 12 Corn Belt States and more than three-fourths of the corn acreage in the three principal corn States, Iowa, Illinois, and Indiana, were planted with hybrid seed. (See Table 1.)

^{2/} Corn Improvement. By Merle T. Jenkins. U. S. Dept. Agr. Yearbook, pp. 455-522. 1936.

Table 1. -- Percentage of corn acreage planted with hybrid seed corn in specified states during 1938, 1939, 1940 and 1941

State	Crop 1938	Crop 1939	Crop 1940	Crop 1941
	Percent	Percent	(Revised) Percent	(Preliminary) Percent
Ohio	25	42	56	74
Indiana	33	51	63	80
Illinois	45	66	76	87
Michigan	4	11	23	42
Wisconsin	13	37	53	64
Minnesota	17	37	59	64
Iowa	40	74	90	95
Missouri	2	13	26	45
North Dakota ^{1/}	--	1	4	6
South Dakota	2	8	12	19
Nebraska	6	13	25	32
Kansas	1	4	8	13
Total of 12 States	22.7	39.1	51.5	61.7

^{1/} First survey made in 1939.

Sources: More than half of middle west corn acreage planted to hybrids. Mimeographed report from Agr. Mkt. Serv., U. S. Dept. of Agr., release Sept. 9, 1940. Nation-wide survey shows over third of U. S. corn acreage planted to hybrids. Mimeographed report from Agr. Mkt. Serv., U. S. Dept. of Agr., release Sept. 17, 1941.

Hybrid corn is the first-generation cross or hybrid involving two or more inbred strains of corn. Not all hybrids are good producers, but from good hybrids a 15 to 20 percent increase in yield can generally be expected over nonhybrid corns. Also, it is claimed that earlier maturing and sturdier plants are obtained. The full value of hybrid seed exists only in the first hybrid generation. The second generation crop will yield less than the first generation, and may be inferior to that of ordinary varieties.

The four different kinds of hybrids commonly produced are: (1) the single cross which involves only two inbred strains; (2) the three-way cross involving three inbred strains; (3) the double cross involving four inbred strains; and (4) the top cross involving one inbred strain and one open-pollinated variety. Each of these has certain advantages and disadvantages or fits into the corn-breeding program in a particular way.

Advantages of Different Hybrids ^{3/}

Any of these hybrids can be planted for commercial corn production. The single cross is at a disadvantage because of the low yield of seed

^{3/} The What and How of Hybrid Corn. By Frederick D. Richey, U. S. Dept. Agr. Farmers' Bul. 1744. 1939.

and its consequent high cost. Moreover, the irregular size and shape and the generally small kernels of present field-corn inbreds make the commercial utilization of single crosses impractical. Single crosses produce the most uniform plants and ears of any of the hybrids. They accordingly have special value where uniformity is most important. Thus uniformity is highly desirable in sweet corn for canning, and, to some extent, single crosses between inbred strains are being used commercially for this purpose. In field corn, however, three-way and double-cross hybrids will be used unless much better inbred strains are developed than are available at present.

The three-way cross has no particular advantage over the double-cross. It is slightly more uniform but not importantly so. Probably the main reason for the production of three-way crosses commercially has been that it was easier to find three reasonably good inbred strains than four. The serious disadvantage of the three-way cross is that an inbred strain must be relied upon to supply pollen for the cross. Unless an inbred that can be counted on for this purpose is available, the three-way cross is impractical. Even a reasonably good pollinating strain requires a somewhat larger proportion of male parent plants with a somewhat higher cost of seed production. For the present and for some time to come, therefore, the double-cross seems to be the most practical source for hybrid seed corn.

The only value of top crosses of field corn for commercial use at present appears to be attributed to the fact that it is easier to find one inbred that will combine well with some standard variety than to find three or four inbreds that will produce a good three-way or double-cross. Experimentally, top crosses provide an efficient means for the preliminary testing of inbred strains for later use in other hybrid combinations.

COMMERCIAL CLASSIFICATION

For commercial purposes corn is divided into the three classes, Yellow, White, and Mixed, according to color. If the corn is of the dent type, the only other designation used is that of "corn." But for corn that consists of 95 percent or more of flint corn, the word "flint" is added to the above class designations. (Example: Yellow Corn, Flint). To corn consisting of more than 5 percent, but less than 95 percent of flint corn, the terms "flint and dent corn" are added to these class designations, (Example: Yellow Corn, Flint and Dent) but to corn consisting of 95 percent or more of dent corn, only the term "corn" is added.

Each of these classes is divided into five numerical grades and "Sample" grade according to certain specified limitations in weight per bushel, content of moisture, cracked corn and foreign material, total damaged kernels, heat-damaged kernels, and certain other factors.

The proportion of commercial corn falling in the various classes and grades is shown in tables 2 and 3, which include the exceptionally high-quality crop of 1939, and the exceptionally low-quality crop of 1935.

Table 2. -- Corn Classes; Percentages. (Based on inspected receipts at representative markets from December through March of the crops of 1934,-35,-37,-38, and -39) 1/

Class	Percentages of inspections by crops				
	1934	1935	1937	1938	1939
Yellow	81	74	85	84	88
White	15	20	8	10	9
Mixed	4	6	7	6	3

1/ See footnote to Table 3.

Table 3. -- Corn Grades; Percentages. (Based on inspected receipts at representative markets from December through March of the crops of 1934,-35,37,-38, and -39) 1/

Grade	Percentages of inspections by crops				
	1934	1935	1937	1938	1939
		<u>Yellow Corn</u>			
1	6	0	2	16	36
2	22	2	14	40	51
3	49	5	32	30	11
4	20	22	37	11	1
5	2	57	13	2	0
Sample	1	14	2	1	1
		<u>White Corn</u>			
1	4	0	8	28	44
2	29	1	10	48	48
3	45	2	33	19	7
4	18	20	39	3	0
5	3	55	8	1	0
Sample	1	22	2	1	1
		<u>Mixed Corn</u>			
1	2	0	2	32	38
2	18	1	15	38	46
3	39	3	33	21	11
4	28	19	36	7	3
5	8	52	11	1	0
Sample	5	25	3	1	2
		<u>All Corn</u>			
1	6	0	2	18	37
2	23	1	13	41	51
3	48	4	33	28	11
4	20	22	37	10	1
5	2	57	13	2	0
Sample	1	16	2	1	0

1/ Compiled from data by Grain and Seed Division, Agricultural Marketing Service of the U. S. Department of Agriculture

STRUCTURE OF KERNEL

There are three distinct parts to the corn kernel, the pericarp, germ, and endosperm. Each is structurally and chemically different. The pericarp or thin outer hull seems to be largely a combination of hemicellulose and cellulose with some protein and lignin. The germ contains considerable protein, most of the oil, and a large share of the minerals. The endosperm is of two kinds. The one is soft and floury and consists almost entirely of starch, and the other is corneous and translucent and consists of a mixture of starch and gluten.

Figure 1. -- Kernel structure of dent and flint corn



Dent



Soft endosperm
Corneous endosperm
Germ

Flint

The pericarp, or hull, constitutes about 6 percent of the corn kernel, the endosperm about 84 percent, and the germ about 10 percent. ^{4/} Other details regarding structure are shown in figure 2. (See page immediately following.)

COMPOSITION

Table 4 to 8 present data showing the composition of corn. These data cover only open pollinated varieties. In three of the tables positive information is lacking regarding the type of corn represented, but in these instances dent is probably the type, owing to its great preponderance over all other types on the domestic market.

In table 4 the following percentage composition, moisture-free basis, is shown for yellow corn, the class of corn of most common occurrence: Protein, 10.6; fat, 5.9; nitrogen-free extract, 79.6; crude fiber, 2.4; and ash, 1.6. Of the total amount of crude fiber in a kernel of corn ^{5/}, 51 percent is in the hull; of the starch, 90 percent is in the endosperm; of the protein, 80 percent is in the endosperm and 16 percent in the germ; and of the fat, 65 percent is in the germ.

^{4/} U. S. Dept. Agr. Farmers' Bul. 559.

^{5/} See footnote 4.

STRUCTURE OF CORN KERNEL

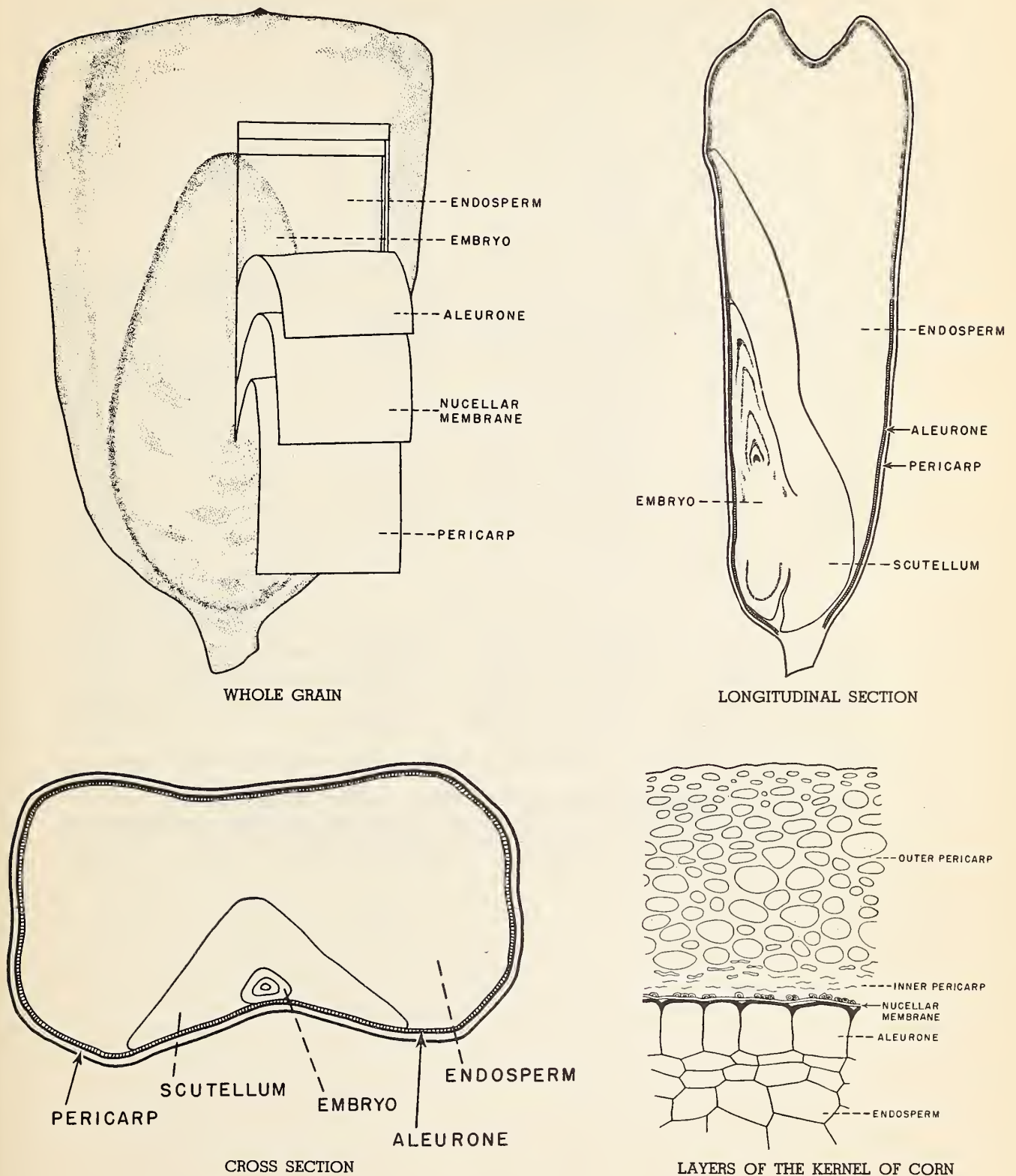


Figure 2. - Structure of Corn Kernel

(Copy of corn chart No. 10.2 prepared by Extension Service in cooperation with Bureau of Plant Industry, U. S. Department of Agriculture)

Table 4. -- Composition of corn and the products and byproducts of corn milling

Product	Analysis calculated to moisture-free basis				
	Protein (N x 6.25)	Fat	Nitrogen-free extract	Crude fiber	Ash
White corn, products, and byproducts:	Percent	Percent	Percent	Percent	Percent
Corn.....	10.55	4.19	81.51	2.34	1.41
Grits, coarse.....	10.10	.55	88.33	.61	.41
Grits, fine.....	9.85	.73	88.39	.55	.48
Meal, cream.....	8.92	1.60	88.20	.64	.64
Meal, brewers'.....	9.08	1.40	88.12	.73	.67
Flour.....	7.63	3.23	87.40	.90	.84
Germ.....	17.80	25.48	43.17	6.47	7.08
Germ cake.....	20.66	7.42	55.58	8.07	8.27
Feed (including bran).....	13.13	9.48	68.54	5.65	3.20
Bran.....	9.38	7.47	69.93	10.82	2.40
Yellow corn, products, and byproducts:					
Corn.....	10.58	5.89	79.60	2.38	1.55
Meal, bolted, coarse.....	11.23	1.03	86.77	.52	.45
Meal, bolted, fine.....	10.46	2.52	85.71	.61	.70
Germ.....	15.04	20.37	55.51	4.49	4.59
Bran.....	10.11	12.27	63.81	10.80	3.01

Source: Composition of Corn (Maize) Meal Manufactured by Different Processes and the Influence of Composition on the Keeping Qualities, U. S. Dept. Agr. Dept. Bul. 215.

Table 5. -- Composition of flint and dent corn

Constituent	: Average of 4 cargoes : Average of 4 cargoes	
	: of Argentine flint : of U. S. dent corn of	
	: corn of 1912 crop : 1910 and 1911 crops	
	: imported at New York : exported from the U. S.	
	Percent	Percent
Ash	1.72	1.43
Ether extract (oil)	5.52	4.07
Protein	11.01	9.81
Crude fiber	1.99	2.18
Pentosans	6.02	6.19
Invert sugar	.30	.38
Sucrose	1.08	1.13
Acid calculated		
as acetic	.33	.28
Undetermined	72.03	74.53
	<u>100.00</u>	<u>100.00</u>

Source: Agricultural Marketing Service, Processed pamphlet, U.S.G.S.A.-GI-31.

Table 6. -- Germ composition

Constituent	Percent
Moisture	1.6
Oil	56.5
Protein	11.5
Fiber	9.0
Starch	8.0
Water soluble	2.6
Mineral matter	1.0
Pentosans and undetermined	9.8
	<u>100.0</u>

Source: Wet Process Corn Milling. By F. W. Bartling. Amer. Miller, Feb., 1940.

Table 7. -- Corn ash composition.

Constituent	Percent
Phosphorus pentoxide	47.60
Potassium oxide	29.47
Magnesium oxide	14.39
Calcium oxide	1.90
Silica	2.27
Sodium oxide	1.43
Iron and aluminum oxides	1.22
Sulphur trioxide	.67
Chlorine in chlorides	.78
	<u>99.73</u>

Source: Wet Process Corn Milling. By F. W. Bartling. Amer. Miller, Feb., 1940.

Table 8. -- Kernel composition of corn of the grade as processed in one of the larger wet-process corn milling plants

Constituent	Percent	Lbs. per bushel
Moisture	18.5	10.36
Starch	55.5	31.08
Protein	8.2	4.59
Oil	3.0	1.68
Fiber	2.4	1.34
Ash	1.5	.84
Pentosans	5.1	2.86
Water soluble and undetermined	5.8	3.25
	<u>100.0</u>	<u>56.00</u>

Source: Wet Process Corn Milling. By F. W. Bartling. Amer. Miller, Dec., 1939.

Moisture $\frac{6}{100}$ in Corn

A wider range exists in the moisture content of market corn than in that of any other market grain. This range is commonly from a low of 10 percent to a high of 24 percent. The maximum percentage of moisture in corn which assures safe transportation and storage is approximately the same as in the other grains; namely about 14 to 15 percent, and varies somewhat with environmental conditions. Corn is harvested and the bulk of it is marketed during weather usually cooler than that prevailing when the small grains are marketed. For that reason shelled corn containing 16 to 18 percent moisture is often transported to the markets or to the livestock-feeding areas without undue risk of heating, although it contains too much moisture for elevator storage. Moisture content is the principal factor in determining the grade of market corn, and is of special significance during autumn, winter, and the early spring months.

PRODUCTION

Corn production in the United States during the 10-year period 1928-37 averaged approximately 2.3 billion bushels as compared with a world total of approximately 4.5 billion bushels. During the period 1910 to 1933 approximately 100 million acres of land were used annually in corn production in the United States, whereas in 1940 there were approximately 87 million acres used. According to the 1935 census of agriculture, corn was produced on 4,849,724 farms, or 71.2 percent of the total number of farms in the United States. It is an especially important crop in nearly all of the central and eastern part of the country. In the western and extreme northern parts of the country, corn is not an important crop, owing chiefly to climatic conditions unfavorable to its growth.

Table 9 presents data showing world production of corn, and tables 10, 11, and 12 show data on acreage, production, and yield of corn in the United States.

RELATIVE VALUE AS A FARM CROP

Of all the crops produced by the American farmer, the corn crop has by far the greatest farm value. In some seasons it constitutes as much as one-third of the total farm value in all field and garden crops. Its value, however, cannot be considered in the same light as that of wheat, practically all of which is sold for cash; whereas only a small proportion of the corn crop is sold for cash, its principal value being for use as livestock feed. The average farm value of corn in the pre-war period, 1910 to 1914, was \$1,577,000,000 annually. The higher prices resulting from the World War raised the average annual value in the 1915-1919 period to \$3,024,000,000. The 1920 crop, the largest ever harvested, was valued at \$2,150,000,000. The estimated value of the 1938 crop was \$1,282,064,000.

Table 9. -- World corn production 1921-1939

Year of harvest 1/	Estimated world total	Selected countries									
		United States	Danube Basin	Argentina:	Brazil	Soviet Union	Italy	Union of So. Africa			
		Million bushels	Million bushels	Million bushels	Million bushels	Million bushels	Million bushels	Million bushels			
1921	4,499	2,928	233	176	212	46	92	48			
1922	4,427	2,707	275	176	217	118	77	71			
1923	4,763	2,875	309	277	221	125	89	40			
1924	4,188	2,223	404	186	194	92	106	87			
1925	4,959	2,798	427	322	176	177	110	39			
1926	4,738	2,547	468	321	172	136	118	65			
1927	4,669	2,616	311	312	201	123	87	69			
1928	4,580	2,666	250	252	185	130	65	67			
1929	4,740	2,521	522	281	207	119	99	80			
1930	4,358	2,080	400	420	198	105	118	57			
1931	4,866	2,576	460	299	187	187	77	68			
1932	5,265	2,931	555	268	227	135	119	30			
1933	4,647	2,400	429	257	221	189	102	86			
1934	3,903	1,461	507	452	208	151	126	66			
1935	4,644	2,304	427	396	234	110	98	54			
1936	4,052	1,507	561	340	225	163	120	101			
1937	4,980	2,651	540	174	228	153	134	69			
1938	4,875	2,562	514	191	239	106	116	104			
1939	5,108	2,602	527	408	234	---	102	74			
1940 2/	5,054	2,449	498	411	---	---	135	79			

1/ Except harvests for Southern Hemisphere which are for year immediately following the designated year.

2/ Preliminary.

Source: U. S. Dept. Agr. Statistics.

Table 11. -- Corn production by regions and Corn Belt States, crops of 1939, 1940, and average for 1929-38

Region or State	All Corn			For Grain Only	
	Average				
	1929-38	1939	1940	1939	1940
<u>Non Corn Belt</u>	<u>1,000</u>	<u>1,000</u>	<u>1,000</u>	<u>1,000</u>	<u>1,000</u>
	<u>bushels</u>	<u>bushels</u>	<u>bushels</u>	<u>bushels</u>	<u>bushels</u>
New England	7,905	8,081	7,621	1,390	1,146
Middle Atlantic	81,517	89,787	82,463	56,492	51,259
South Atlantic	177,556	188,947	195,742	181,525	188,230
East So. Central	205,604	192,668	223,569	188,200	218,891
West So. Central	159,878	156,235	197,711	147,463	190,926
Rocky Mountain	23,381	16,142	19,896	11,529	14,043
Pacific	<u>5,378</u>	<u>5,190</u>	<u>5,246</u>	<u>2,886</u>	<u>2,937</u>
Non Corn Belt Total	661,219	657,050	732,248	589,485	667,432
<u>Corn Belt States</u>					
Ohio	134,812	171,250	120,750	161,800	112,912
Indiana	152,216	213,416	145,669	204,867	136,937
Illinois	311,056	413,296	332,244	399,256	318,296
Michigan	44,978	58,830	49,856	45,904	38,049
Wisconsin	72,844	85,970	93,582	40,053	43,036
Minnesota	138,187	204,796	172,457	167,132	135,136
Iowa	394,166	494,312	460,581	471,588	442,425
Missouri	107,653	120,118	119,280	116,082	112,789
North Dakota	16,025	16,995	24,480	3,325	5,824
South Dakota	48,802	46,848	50,112	39,620	41,249
Nebraska	149,599	82,032	106,913	74,646	90,558
Kansas	<u>67,786</u>	<u>37,220</u>	<u>41,028</u>	<u>28,952</u>	<u>31,104</u>
Corn Belt Total	1,638,124	1,945,083	1,716,952	1,753,225	1,508,315
All U. S.	2,299,343	2,602,133	2,449,200	2,342,710	2,175,747

Source: Crops and Markets. U. S. Dept. Agr. Dec., 1940.

Table 12. -- Corn yields per acre, by regions and Corn Belt States crops of 1939, 1940, and average for 1929-38

Region or State	All Corn			For Grain Only	
	Average				
	1929-38	1939	1940	1939	1940
<u>Non Corn Belt</u>	<u>Bushels</u>	<u>Bushels</u>	<u>Bushels</u>	<u>Bushels</u>	<u>Bushels</u>
New England	39.9	40.0	39.7	40.0	39.7
Middle Atlantic	37.3	38.5	36.6	38.5	37.2
South Atlantic	19.6	21.2	21.4	21.2	21.4
East So. Central	17.9	16.9	19.1	16.9	19.1
West So. Central	14.4	15.2	19.5	15.2	19.5
Rocky Mountain	18.2	18.8	20.2	19.9	21.3
Pacific	32.4	33.2	35.2	34.0	35.8
<u>Corn Belt States</u>					
Ohio	37.2	50.0	37.5	50.0	37.5
Indiana	34.1	51.5	37.0	51.5	37.0
Illinois	34.6	52.0	44.0	52.0	44.0
Michigan	29.7	37.0	32.0	38.0	33.0
Wisconsin	32.1	38.5	41.5	39.0	41.5
Minnesota	29.6	45.5	39.5	47.0	41.0
Iowa	36.0	52.0	51.0	52.0	51.0
Missouri	19.9	29.0	30.0	29.5	30.5
North Dakota	13.7	16.5	24.0	19.0	26.0
South Dakota	11.7	17.5	18.0	20.0	19.0
Nebraska	16.0	12.0	17.0	13.0	18.0
Kansas	12.7	13.5	15.5	14.0	16.0
All U. S.	23.2	29.4	28.3	29.8	28.5

Source: Crops and Markets. U. S. Dept. Agr. Dec., 1940

As a cash income crop to the farmer, corn ranks a poor fourth. In this respect it is outranked by wheat, cotton, and tobacco.

Table 13 shows the farm value of various crops, and table 14, the cash income from these crops.

PRESENT USES

Of the 2.5 billion bushels of corn produced each year, an average of approximately four-fifths is utilized on the farm where produced for feed, food, and seed purposes. The remaining one-fifth, or approximately 500 million bushels, is sold off of the farm of production. Of the quantity sold ordinarily over one-half is sold to other farmers in the vicinity of its production so that only approximately 250 million bushels might be considered as commercial corn according to the usual interpretation of this term. A small portion (averaging about twenty to thirty million bushels annually, but varying greatly from year to year) of this is exported. The remainder is used domestically for food, feed (in the form of commercial feeds), and industrial purposes (See table 15).

Data from the U. S. Department of Agriculture Yearbook for 1921 show that corn production from 1911 to 1921 was utilized as follows:

Fed to hogs on farms.	40.0%
Fed to horses and mules on farms.	20.0%
Fed to cattle on farms.	15.0%
Fed to poultry on farms.	4.0%
Fed to sheep on farms.	1.0%
Human food on farms.	3.5%
Fed to stock not on farms.	5.5%
Ground in merchant mills (dry milling).	6.5%
Exports.	1.5%
Other uses.	3.0%
	<u>100.0%</u>

Table 16 shows the utilization of corn for the periods 1925-29 and 1930-34

The decrease in the 1930-34 period of 6.3 percent from that in 1921 in the percentage of corn fed to horses and mules has been due largely to the continued substitution of mechanical for animal power in transportation and farm operations.

Seed

The quantity of corn used for seed is relatively small compared with production. The quantity required to plant an acre varies with soil fertility, average rainfall, length of growing season, intended use, and a few other factors. Depending upon these factors, plantings per hill of corn may vary from 2 to 5 kernels. The average seed used for plantings for both grain production and silage, including any replantings necessary, is about 9.5 pounds per acre. Thus, for planting the United States corn acreage, which amounts to approximately 90 million acres annually, a quantity in the neighborhood of 15 million bushels of corn is used.

Table 13. -- Farm value of various crops, 1936-1940

Commodity	1936	1937	1938	1939	1940 <u>1/</u>
	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000
Corn, all	1,573,865	1,372,468	1,247,010	1,476,300	1,434,948
Wheat	642,859	842,843	522,639	519,651	545,093
Oats	352,614	350,003	253,455	290,922	364,576
Barley	115,681	119,075	92,609	110,826	119,445
Rye	20,485	34,172	18,783	17,163	16,423
Buckwheat	5,357	4,525	3,619	3,560	3,442
Flaxseed	10,002	13,222	12,965	29,492	42,822
Rice	41,567	35,132	33,630	39,095	41,230
Grain Sorghums	52,207	47,656	38,932	46,970	56,784
Cotton Lint	764,433	796,179	513,638	536,923	590,824
Cottonseed	183,336	164,375	115,695	111,259	121,581
Tobacco	272,895	319,465	269,184	285,036	2/
Potatoes	378,337	208,785	208,835	251,586	214,734
Peanuts	49,601	63,137	67,434	58,728	77,340
Hay, all	776,911	721,646	618,676	671,329	715,073
Soybeans <u>3/</u>	38,409	38,178	42,376	74,299	63,702
Other	904,598	938,447	855,412	825,476	1,270,002 <u>4/</u>
Total, 65 crops:	6,183,157	6,069,308	4,914,892	5,348,615	5,678,019

1/ Preliminary.

2/ Figure not available.

3/ For beans only.

4/ Figure for tobacco included.

Source: U. S. Dept. Agr. Statistics.

Table 14. -- Cash farm income in the United States for calendar years 1936-1940

Commodity	1936	1937	1938	1939 1/	1940 1/
<u>Crops</u>	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000
Corn	264,918	222,693	268,516	318,931	369,777
Wheat	450,859	604,910	400,101	432,004	447,044
Oats	47,333	67,022	42,850	45,762	58,590
Barley	45,595	42,673	38,259	39,842	46,869
Rye	15,196	19,856	8,582	9,016	9,519
Buckwheat	1,837	1,941	1,467	1,553	1,284
Flaxseed	10,397	13,062	12,063	26,950	38,359
Rice	31,556	32,591	34,042	32,903	38,434
Grain Sorghums	7,628	8,332	7,504	6,826	8,274
Cotton Lint	763,360	769,890	558,303	550,046	573,401
Cottonseed	141,519	113,399	88,670	78,529	86,434
Tobacco	243,169	320,518	294,035	268,597	240,369
Potatoes	229,820	183,736	127,651	156,215	165,062
Hay	85,729	93,897	60,449	67,035	69,515
Soybeans	28,745	31,073	34,405	50,871	55,765
Other	1,207,451	1,400,925	1,215,856	1,286,621	1,327,016
Total crops	3,575,112	3,926,518	3,192,753	3,371,701	3,535,712
Livestock and livestock products	4,636,929	4,861,450	4,459,074	4,486,276	4,821,657
Government payments	287,252	366,899	482,221	807,065	765,799
Grand total	8,499,293	9,154,867	8,134,048	8,665,042	9,123,168

1/ Preliminary.

Source: Gross Farm Income and Government Payments. U. S. Dept. Agr., Bur. Agr. Econ. May 26, 1941.

Table 15. -- Commercial corn, supply, and disposition 1920 to 1939 1/

Crop	Supply			Disposition					
	Sold from farms	Im-ports 2/	Im-ports 3/	Total	Ex-ports 3/	Alcohol & distilled spirits 4/	Fermented malt liquors 4/	Wet process grindings 3/	Other commercial uses, chiefly feed 5/
	: 1,000 bu.	: 1,000 bu.	: 1,000 bu.	: 1,000 bu.	: 1,000 bu.	: 1,000 bu.	: 1,000 bu.	: 1,000 bu.	: 1,000 bu.
1920-21	: 707,766	: 1,059		: 708,825	: 115,373	: 4,811	: No data	: 47,745	: 540,896
1921-22	: 602,375	: 104		: 602,479	: 167,806	: 3,093	: "	: 67,898	: 363,682
1922-23	: 499,492	: 154		: 499,646	: 63,695	: 3,106	: "	: 66,227	: 366,618
1923-24	: 588,811	: 2,295		: 591,106	: 21,811	: 4,835	: "	: 75,146	: 489,314
1924-25	: 419,479	: 2,892		: 422,371	: 10,486	: 7,201	: "	: 68,127	: 336,557
1925-26	: 588,653	: 357		: 589,010	: 25,424	: 7,948	: "	: 82,780	: 472,858
1926-27	: 467,602	: 3,750		: 471,352	: 18,009	: 8,383	: "	: 82,040	: 362,920
1927-28	: 506,173	: 2,940		: 509,113	: 20,223	: 6,189	: "	: 88,091	: 394,610
1928-29	: 535,553	: 342		: 535,895	: 41,734	: 9,802	: "	: 87,202	: 397,157
1929-30	: 459,318	: 846		: 460,164	: 8,963	: 9,966	: 227	: 79,958	: 361,050
1930-31	: 326,691	: 1,386		: 328,077	: 3,119	: 2,454	: 170	: 66,489	: 255,845
1931-32	: 437,102	: 377		: 437,479	: 4,436	: 4,848	: 116	: 62,463	: 375,016
1932-33	: 553,011	: 173		: 553,184	: 8,886	: 5,818	: 1,011	: 71,815	: 465,654
1933-34	: 403,314	: 883		: 404,197	: 4,812	: 12,777	: 4,587	: 70,540	: 311,481
1934-35	: 136,671	: 36,955		: 173,626	: 1,143	: 20,566	: 6,086	: 55,271	: 90,560
1935-36	: 375,521	: 21,096		: 396,617	: 867	: 31,825	: 8,035	: 75,826	: 280,064
1936-37	: 212,681	: 103,670		: 316,351	: 432	: 36,242	: 7,555	: 66,816	: 205,306
1937-38	: 562,963	: 1,819		: 564,782	: 139,893	: 19,827	: 6,697	: 71,647	: 326,718
1938-39	: 595,788	: 442		: 567,292	: 34,369	: 18,087	: 7,423	: 75,531	: 431,882
1939-40	: 631,958	: 1,110		: 633,068	: 44,284	: 18,911	: 7,877	: 83,074	: 478,922
6/	:	:	:	:	:	:	:	:	:

1/ Stocks at beginning and end of year are disregarded.

2/ Crop year beginning Nov. 1 for 1920-25, and Oct. 1 for other years.

3/ Crop year beginning Oct. 1.

4/ Year beginning July 1.

5/ Supply less exports, alcohol and distilled spirits, fermented malt liquors, and wet-process grindings. Commercial feed is undoubtedly the principal use. Commercial food probably accounts for in the neighborhood of 50 million bushels.

6/ Preliminary. Crop year beginning July 1.

Compiled from official records.

Table 16. -- Corn utilization, 1925-29 and 1930-34

Use	1925-29		1930-34	
	Average amount used annually ^{1/}	Percent of total	Average amount used annually ^{1/}	Percent of total
	Million bushels	Percent	Million bushels	Percent
Horses and mules	397	15.1	315	13.7
Cattle on farms	544	20.7	548	23.8
Hogs on farms	1,062	40.4	914	39.7
Sheep on farms	17	.6	17	.7
Poultry on farms	264	10.0	245	10.6
Livestock not on farms	65	2.5	40	1.7
Industrial and commercial utilization	210	8.0	180	7.8
Exports	21	.8	-4	-.2
Families on farms	31	1.2	32	1.4
Seed	18	.7	18	.8
Average utilization	2,629	100.0	2,305	100.0

^{1/} Average annual production plus decrease in inventory or minus increase in inventory during each of these periods.

Source: U. S. Dept. Agr. Bur. Agr. Econ.

Formerly, most farmers produced their own seed corn, but with the development of the practice of planting hybrid corn, the production of seed corn has become a highly commercialized industry.

Feed

As shown previously, the principal use of corn is for feed. Eighty to ninety percent of the production is used for that purpose, chiefly in the form of grain. Five to six percent of the total acreage is fed in the form of silage, and green fodder, and 6 to 7 percent is hogged down or grazed. In addition, considerable use for feed is made of the stalks from that portion of the crop harvested for grain. (See tables 10, 11, and 12).

The corn crop, hog, beef cattle, and chicken production are related. This is evidenced by the fact that the six States, Iowa, Illinois, Nebraska, Missouri, Indiana, and Ohio, producing 56 percent of the corn in 1940, had within their borders on January 1, 1941 (preliminary figures) about 50 percent of the swine of the country, 25 percent of all cattle, and 30 percent of the chickens.

Considerable study (see U. S. Dept. Agr. Dept. Bul. 1440) has been given to the relationship between the price of corn and the price, production, and feeding of hogs. This study shows that on the average the value of 100 pounds of hogs at the eleven important livestock markets included in the study has equalled the value of 11.4 bushels of corn. Whenever the value of 11.4 bushels of corn is higher than the value of 100 pounds of hogs, the number of hogs and the rate of feeding tends to decrease. On the other hand when the value of 11.4 bushels of corn is lower, the number of hogs and rate of feeding tends to increase. Because the feeding of hogs accounts for approximately 40 percent of the utilization of corn, these tendencies in hog production and feeding naturally in turn have some influence on the market price of corn.

Similar relationships undoubtedly exist between the price of corn and beef cattle and the price of corn and chickens, but probably are less pronounced owing to the fact that corn plays a less important role in the feeding ration of these animals than in the case of hogs.

The feeding of corn to animals is done chiefly on the farm where the corn is produced. This is evidenced by the fact that approximately only one-fifth of the corn produced is sold from the farm.

The relative values per bushel of corn, wheat, and barley for feeding poultry, sheep, hogs, and beef cattle, are shown in table 17.

Table 17. -- Relative values per bushel of corn, wheat, and barley, based on their relative feeding values

When price of corn is -	:Relative feeding value (not including cost of grinding) : for -					
	: Poultry :		: Sheep :		: Hogs and beef cattle :	
	: Wheat :		: Wheat :		: Wheat :	
	: Barley :		: Barley :		: Barley :	
Cents	Cents	Cents	Cents	Cents	Cents	Cents
50	53.5	53.5	40	56	40	
70	75	75	56	79	56	
75	80	80	60	84	60	
80	86	86	64	90	64	
85	91	91	68	96	68	
90	96	96	72	101	72	
95	102	102	76	107	76	
100	107	107	80	112	80	
105	113	113	84	118	84	
110	118	118	88	123	88	
115	123	123	92	129	92	
120	128	128	96	123	96	
125	134	134	100	140	100	

Source: Feeding Wheat to Livestock. U. S. Dept. Agr. Misc. Pub. 96

Food 7/

Corn has long been an important food material in this country but it has been estimated that only 10 percent of the crop is utilized for that purpose (see table 18). According to a "Northwestern Miller" statement the per capita consumption (see table 19) of corn is less than 25 pounds a year, (this figure which constitutes only about 2-1/2 percent of the crop apparently refers only to the use of corn meal and flour and does not include other food uses of corn) less than one-sixth of that of wheat flour, but far greater than that of any other cereal.

Corn, along with the other cereals such as wheat, rice, oats, and rye, contains a large amount of starch and a goodly amount of protein. The most economical, and at the same time adequate, diets are those in which generous amounts of the cereal foods are combined with reasonable amounts of other kinds of food. As a source of energy for the body, corn is capable of producing about 1800 calories per pound.

7/ References:

Corn and Its Uses as Food. U. S. Dept. Agr. Farmers' Bul. 1236.

Composition of Corn (Maize) Meal Manufactured by Different Processes and the Influence of Composition on the Keeping Qualities. U. S. Dept. Agr. Dept. Bul. 215.

Proximate Composition of American Food Materials. U.S. Dept. Agr. Cir. 549.

Table 18. -- Certain data relating to the consumption of corn as food 1/

Year	Corn retained on farm for household use <u>2/</u>	Census reports on milling industry <u>3/</u>	
		Corn ground	Meal and corn- flour produced
	<u>1,000 bushels</u>	<u>1,000 bushels</u>	<u>1,000 pounds</u>
1927	31,435	92,693	1,899,860
1929	30,784	87,453	2,215,075
1931	33,630	58,902	1,777,015
1933	33,768	---	---
1935	33,999	48,656	1,502,704
1937	32,016	48,612	1,456,108
1939	32,495	---	---

1/ Exact data on consumption of corn for food are not available.

2/ Basis crop year.

3/ Corn ground and corn meal, corn flour, and corn feed, produced in merchant mills doing a gross business of more than \$5,000 annually.

Table 19. -- U. S. apparent per capita consumption of corn and other cereals, 1919-20 to 1937-38 ^{1/}

Year	:Corn :meal and :Corn :flour	:Wheat :flour	:Rye :flour	:Buck- :wheat :flour	:Cereal :Cleaned: :rice	:break- :fast :foods	:Total
	: Pounds	: Pounds	: Pounds	: Pounds	: Pounds	: Pounds	: Pounds
1919-20	: 35.0	: 175.0	: 3.1	: 1.0	: 4.9	: (10.0)	: 229.0
1920-21	: 34.4	: 176.0	: 2.7	: .8	: 6.0	: (10.0)	: 229.0
1921-22	: 36.3	: 176.0	: 2.6	: .7	: 4.4	: (10.0)	: 230.0
1922-23	: 35.9	: 176.0	: 2.9	: .6	: 5.1	: (10.0)	: 226.8
1923-24	: 32.5	: 176.0	: 2.4	: .6	: 5.3	: (10.0)	: 224.5
1924-25	: 29.6	: 176.0	: 2.8	: .6	: 5.6	: 9.9	: 224.6
1925-26	: 29.3	: 176.0	: 2.8	: .5	: 5.6	: 10.4	: 224.8
1926-27	: 28.9	: 176.0	: 2.9	: .5	: 5.6	: 10.9	: 226.4
1927-28	: 29.9	: 176.0	: 2.8	: .5	: 5.8	: 11.4	: 226.4
1928-29	: 30.5	: 176.0	: 2.8	: .5	: 5.6	: 11.8	: 227.2
1929-30	: 28.2	: 172.0	: 2.7	: .5	: 5.0	: 11.8	: 220.2
1930-31	: 26.5	: 167.0	: 2.6	: .4	: 5.6	: 11.8	: 213.9
1931-32	: 26.4	: 162.0	: 2.6	: .3	: 5.0	: 10.9	: 207.2
1932-33	: 25.6	: 159.0	: 2.8	: .2	: 5.9	: 10.0	: 203.5
1933-34	: 25.1	: 154.0	: 2.8	: .2	: 4.9	: 9.6	: 196.6
1934-35	: 24.6	: 154.0	: 2.5	: .3	: 5.9	: 9.0	: 196.3
1935-36	: 24.5	: 154.0	: 2.4	: .4	: 5.3	: 9.0	: 195.6
1936-37	: 23.6	: 154.0	: 2.3	: .5	: 6.7	: 9.0	: 196.1
1937-38 ^{2/}	: 23.4	: 154.0	: 2.3	: .3	: 6.4	: 9.0	: 195.4
1938-39 ^{2/}	: 23.4	: 154.0	: (2.3)	: (.3)	: 5.5	: (9.0)	: 194.5

^{1/} Year beginning July 1 for wheat, rye, buckwheat flour; Aug. 1 for rice; and Jan. 1 of the second year indicated, for corn meal and breakfast food.

^{2/} Preliminary estimates.

Source: Northwestern Miller. Apr. 17, 1940. Note: the figures in parenthesis are probably estimates based on figures immediately preceding or following.

The various ways in which corn is used primarily as human food are as follows: Parched grain to be eaten whole; grain ground to varying degrees of fineness to make hominy, corn meal, and corn flour; grain treated with alkali to remove the pericarp (hull) and germ to make lye hominy or hulled corn; or the grain or some product made from it prepared by special processes to make a variety of breakfast foods. Yellow corn is preferred for these uses in the Northern States as a whole; white corn in the Southern States, and Rhode Island; and blue, black, and red corn in the Southwest where Spanish influence is marked. White corn is, as a rule, milder in flavor than yellow corn. Most of the corn consumed as human food is in the form of corn meal.

There are two general methods of grinding corn meal for food. The one is called "old process" and the other "new process". "Old process" meal is also known as "water ground" meal because the mills making it were formerly run by water power. In the southeastern States many of these mills still are run by water power. The grinding in the "old process" is done by stones. In many of the smaller mills of this type, grinding only a few bushels per hour, the ground material coming from the stones is not subjected to any bolting or sieving to remove particles of germ or hull; but in the larger mills using this process some sieving and "purifying" is done, but generally only to remove the coarser particles of hull. It is considered desirable to leave the germ in the meal because its presence improves the flavor and nutritive properties of the product. Unfortunately the germ, which contains most of the fat of the grain, is the part of the grain that spoils first, therefore, retaining it lessens the keeping quality of the product.

"New process" meal is ground between steel rolls or cylinders and purified and sieved with intricate modern equipment, similar to that employed in the manufacture of wheat flour. The method or process used consists of gradually reducing the kernel in such a manner that the hull and any germ present may be preserved in as large particles as possible to insure their easy and complete removal after the endosperm particles have been detached therefrom and that the soft endosperm particles may readily be separated from the corneous endosperm particles. Usually this process includes a special degermination operation preceding that of grinding.

Among the foods that are made from corn meal are mush, polenta, corn bread, griddle cakes, waffles, scrapple, cakes and puddings. It is also sometimes used as a dusting flour in the baking of hearth breads.

Corn flour is corn meal ground and bolted until it is as fine as wheat flour. It is generally produced in conjunction with meal by the "new process" of milling, and as such represents the more starchy portion of the endosperm. Corn flour is used by bakers and as a binder in sausage making. During the war, it was used as a partial substitute for wheat flour in bread, cakes, and general baking. Some pancake flours contain a small proportion of corn flour. Corn flour should not be confused with cornstarch, the pure starch product of wet-process corn milling.

Hominy consists of coarsely broken corn endosperm. Hominy may be prepared by the "new process" or dry-milling method used in the production of meal, but the modern method is to soak the grain for the purpose of softening it. It is then passed through a machine called a degerminator, which breaks the grain into coarse pieces and loosens the bran and germ which are sifted out. The coarse particles of endosperm resulting from the degerminator operation are dried. When left in fairly large pieces, it is known as samp or pearl hominy; when ground to a very coarse meal, it is called hominy grits. Any kind of hominy may be used like rice, in place of a vegetable, or for a breakfast cereal. Hominy grits may also be used in puddings and cakes.

Lye hominy, or hulled corn, is a special preparation made by soaking the whole grain in water containing lye or sometimes merely a bag of wood ashes, until the hulls are loosened or softened, then washing the hulled grains in clear water and boiling. It is used in the same way as coarse hominy.

Aside from corn meal and hominy of various kinds, commonly used as breakfast cereals, there are on the market other preparations of corn intended for food uses. These are mostly of the pre-cooked type and either may be eaten cold or may require only warming to make them ready to serve. Most are steam cooked and roasted. Some are pressed into flakes and others are treated by a process resembling shredding. In some cases, malt and other materials are added to improve the flavor or nutritive properties. A recent food preparation of corn consists of buttered and salted parched kernels.

Industrial Uses

Up to this time the so-called industrial use of corn has been confined to two general fields, namely, the production of starch or starch derivatives and the byproducts associated therewith, and the production of alcohol, alcoholic products, or organic acids.

The quantity of corn used at the present time (1939) for starch production is approximately 80 million bushels. The cornstarch thus produced constitutes more than 98 percent of all the starch produced in the United States.

Industrial- and beverage-alcohol production utilizes about 18 million bushels of corn annually (see table 15), of which only 2.5 million bushels are used for industrial-alcohol purposes. The alcohol now produced from corn or its derivatives is of the ethyl kind and goes into either potable beverages or other special relatively high cost uses. The possibility of its use for motor fuel either as the main constituent or as an addition agent to impart valuable characteristics to the fuel has been demonstrated, but as yet has not been found economically feasible. Formerly a considerable quantity of corn was used in the production of butyl alcohol and acetone, but the latest tendency has been to supplant this use with molasses. The ethyl alcohol yield from corn amounts to about 2.35 wine gallons of anhydrous pro-

duct per bushel (56 lbs.) of shelled corn and the butyl alcohol-acetone yield amounts to about 1.5 to 2 wine gallons of product per bushel (56 lbs.) of shelled corn. 8/

Wet-process milling of corn

The industrial use of corn for starch making 9/ in the United States was begun about 1850 by the Kingsfords and Duryeas with factories located at Oswego, New York, and near Hempstead on Long Island, grinding at the rate of several hundred bushels a day.

Since 1880 the industry, in order to be located where corn is cheapest and most abundant, has shifted to the Corn Belt where it has expanded to its present proportions. Table 20 lists the names and locations of the companies 10/ engaged in the manufacture of starch (wet-process corn milling) together with the quantities of corn milled annually by each, as reported by Bartling 11/. The production data given in the table are reported as representing those of a typical year of substantial business.

The process 12/ used in the manufacture of cornstarch is known as the wet-process. In this process the shelled corn, from which the dirt has been removed, is softened by steeping for 30 to 40 hours in water containing sulfur dioxide in solution. Then it is coarsely ground to loosen the germs which are removed by settling. Oil is obtained from these germs either by pressing or by solvent-extracting methods. The material left after removing the germs is then more finely ground, and the hulls and fiber screened out. The resulting liquor, composed of gluten and starch suspended in water, is run on long narrow tables where the starch settles to the bottom and the gluten and water run off. The substance left on the tables is starch which may be either further purified for marketing or converted into sirup, sugar, or dextrin. Zein (alcohol soluble protein), which is somewhat similar to gluten in wheat, is extracted from the protein material of the corn. It is a valuable material for the production of water- and scuff-proof plastics.

Table 21 presents data showing the quantities of cornstarch, cornstarch derivatives, and byproducts sold annually by the wet-process mills for the years from 1927-38, and table 22 gives data showing the uses of cornstarch.

8/ Motor Fuels from Farm Products. By P. Burke Jacobs and Harry P. Newton. U. S. Dept. Agr. Misc. Pub. 327.

9/ Wet-Process Corn Milling. By F. W. Bartling, Amer. Miller, Dec., 1939.

10/ In listing the names of companies herein, it is to be understood that their products are not recommended over those of any others engaged in the same line of business, but their names are furnished merely for the convenience and information of those interested.

11/ See footnote 9.

12/ Starches, Dextrines, and Related Products. Rept. No. 138, Second Series, U. S. Tariff Commission.

Table 20. -- Wet-process corn mills and quantities of corn milled annually

Company	Location	Corn Utilized	
		Quantity	Proportion of total
		Bushels	Percent
Anheuser-Busch	St. Louis, Mo.	2,475,650	3.4
American Maize-Products	Roby, Indiana	7,215,578	9.8
The Clinton Co.	Clinton, Iowa	7,429,666	10.0
Corn Products Refining Co.	Argo, Illinois et al.	30,192,999	41.0
Hubinger Bros.	Keokuk, Iowa	2,402,187	3.3
Huron Milling Co.	Harbor Beach, Mich.	486,598	1.2
Keever Starch Co.	Columbus, Ohio	452,536	.6
Penick & Ford	Cedar Rapids, Iowa	7,704,103	10.5
Piel Bros.	Indianapolis, Ind.	1,931,049	2.6
A. E. Staley Mfg. Co.	Decatur, Ill.	10,130,707	13.8
Union Starch & Refg. Co.	Granite City, Ill.	2,820,200	3.8
		<u>73,241,273</u>	<u>100.0</u>

Source: Wet-Process Corn Milling. By F. W. Bartling. Amer. Miller, Dec., 1939.

Table 21. -- Corn products sold by the wet-process corn milling industry, 1927-39 1/

Part I						
Derivatives from cornstarch						
Years:	Cornstarch	Sirup <u>2/</u>	Sugar	Dextrine	Misc. starch <u>4/</u>	Misc. refinery products <u>6/</u>
	: 1,000 Lbs.	: 1,000 Lbs.	: 1,000 Lbs.	: 1,000 Lbs.	: 1,000 Lbs.	:
1927	: 906,476	: 1,064,821	: 896,739	: 103,340	: --	: 7/
1928	: 838,605	: 1,106,957	: 968,601	: 110,169	: --	: 7/
1929	: 879,560	: 1,111,153	: 894,986	: 114,486	: --	: 7/
1930	: 710,525	: 1,025,970	: 849,315	: 89,720	: --	: 7/
1931	: 635,207	: 929,342	: 802,052	: 79,136	: 5/	: 45,552 <u>8/</u>
1932	: 529,329	: 794,926	: 776,854	: 62,122	: 5/	: 62,424 <u>8/</u>
1933	: 741,854	: 1,000,941	: 842,481 <u>3/</u>	: 86,222	: 29,223	: 48,729 <u>8/</u>
1934	: 666,869	: 996,172	: 634,412 <u>3/</u>	: 69,947	: 26,912	: 69,574 <u>8/</u>
1935	: 636,373	: 942,332	: 363,379 <u>3/</u>	: 71,856	: 32,095	: 1,986
1936	: 849,573	: 1,154,144	: 426,529 <u>3/</u>	: 93,352	: 44,412	: 6,701
1937	: 730,860	: 1,033,468	: 417,849	: 83,314	: 50,501	: 14,171
1938	: 912,225	: 1,080,266	: 412,479	: 80,581	: 35,468	: 19,563
1939	: 1,009,556	: 1,142,488	: 458,762	: 97,875	: 47,356	: 28,122

Part II					
Byproducts of cornstarch manufacture					
Corn oil			Feed		
Years:	Crude	Refined	Miscellaneous, (soap stock, etc.)	Gluten	Oil cake and oil cake meal
	: 1,000 Lbs.	: 1,000 Lbs.	: 1,000 Lbs.	: 1,000 Lbs.	: 1,000 Lbs.
1927	: 39,524	: 67,511	: 7/	: 1,295,095	: 75,054
1928	: 43,507	: 74,153	: 7/	: 1,317,534	: 79,071
1929	: 53,661	: 78,913	: 7/	: 1,268,135	: 54,767
1930	: 40,004	: 77,924	: 7/	: 1,152,242	: 49,664
1931	: 41,076	: 71,537	: 10,845	: 958,248	: 41,656
1932	: 35,127	: 76,437	: 9,320	: 1,084,456	: 36,067
1933	: 37,246	: 81,153	: 10,631	: 1,015,187	: 45,614
1934	: 42,400	: 87,109	: 9,628	: 1,198,066	: 42,703
1935	: 27,200	: 82,077	: 9,604	: 943,913	: 36,178
1936	: 19,825	: 105,446	: 12,462	: 1,125,131	: 53,679
1937	: 19,599	: 113,357	: 10,663	: 1,084,914	: 57,696
1938	: 15,361	: 113,851	: 11,790	: 1,036,492	: 43,774
1939	: 31,673	: 103,583	: 10,792	: 1,183,678	: 55,402

1/ Domestic and export sales.

2/ Includes corn sirup unmixed sold as such; also the corn sirup unmixed used in the mixed sirup produced by the wet-process corn milling industry.

3/ Includes a small quantity of liquid sugar.

4/ Products of which cornstarch is one component.

5/ Included in miscellaneous refinery products.

6/ Products of which corn sirup or corn sugar constitute one component.

7/ Not available.

8/ Including hydrol. a byproduct of the manufacture of sugar; excluding hydrol after 1935.

Source: Starches, Dextrines, and Related Products. Rept. No. 138, Second Series. U. S. Tariff Commission

Table 22. -- Uses of Cornstarch: Proportions sold in principal starch-consuming industries, 1933 and 1935-37

Utilization	1933	1935	1936	1937
	Percent	Percent	Percent	Percent
Foods	25.1	32.5	32.4	30.7
Textiles	19.4	15.6	17.3	17.9
Dextrines and adhesives	12.3	11.9	11.5	11.9
Laundries	20.8	18.5	17.7	17.6
Papermaking	10.5	10.5	10.8	11.5
Miscellaneous	11.9	11.0	10.3	10.4
	100.0	100.0	100.0	100.0

Source: Starches, Dextrines, and Related Products. Rept. No. 138, Second Series, U. S. Tariff Commission.

The following tabulation shows the products and byproducts of wet-process corn milling and their uses: 13/

Products

Cornstarch--Food uses

- In pies.
- In puddings.
- In custards.
- In ice cream.
- In sauces and gravies.
- In baking powder.
- In gumdrops and some other candies, and as a moulding material for use in casting cream centers, marshmallows, bon bons, etc.

Cornstarch--Industrial uses

- In the laundry.
- As sizing for stiffening and finishing yarns and fabrics in textile industries.
- In the manufacture of paper as a filler, finisher, and for sizing.
- For cosmetics, pastes and adhesives, etc.
- In the manufacture of high explosives.
- In the manufacture of flashlight and radio batteries.

Dextrin uses

- As a sizing in the textile industry for strengthening the fiber and finishing the fabric.
- For thickening colors, for printing calico and other textiles.

13/ Corn in Industry. By Corn Industries Research Foundation 1939.
The Story of a Grain of Corn. By Associated Corn Products Manufacturers.

Dextrin uses (continued)

For gums, and glues, ink, mucilage, and adhesives.
In the fireworks called "sparklers."
Core binder for foundries.

Crude corn oil uses

Black grease.
Soap.
Artificial rubber (Factice).
Paint.
Varnish.
Glycerine.
Cotton softener.

Refined corn oil uses

For frying and cooking.
As shortening for bread and pastry.
As a salad oil.
For corn popping.
In medical preparations.

Corn syrup uses

For mixing with cane syrup, sorghum, and molasses in the preparation of mixed table syrups.
For confectionery.
In baking.
In jams, jellies, preserves, mincemeat, and food sauces.
In the manufacture of ice cream.
In making lactic acid.

Refined white corn sugar (dextrose) uses

For infant feeding.
For diabetics.
For sugar tolerance test.
For surgical shock (intravenously).
In the manufacture of ice cream.
In bread making.
In condensed milk.
In fruit canning.
In the manufacture of candy.
In making lactic acid.

"70 and 80" corn sugar uses

Caramel or sugar coloring.
Vinegar.
In the manufacture of lactic acid.
In tanning.
In the manufacture of rayon.

Zein (a derivative of corn protein) uses

Plastics.
Water proofing paper.

Byproducts -- all used as **feed** for livestock

- Corn bran.
- Corn gluten.
- Corn gluten meal.
- Corn oil cake.
- Corn oil cake meal.

Alcohol process

The process generally used in the United States for production of alcohol, whether for fuel or for spiritous beverages, is essentially one of fermentation followed by distillation. The first step in this process is the cleaning and grinding of the grain. In a few instances puffing, or exploding, is substituted for grinding. If the alcohol to be produced is for the making of spiritous beverages, it is essential that the grain be clean and free from fungi and bacteria, otherwise it is difficult to control the fermentation processes which are responsible for the quality of the product. If musty grain is used, there is danger of introducing a deleterious flavor. When corn is used, a rough separation of the germ is sometimes made for oil extraction purposes. Some water is added to the ground material which is then heated with steam under pressure to gelatinize the starch. The resulting softened and disintegrated material is blown into a vat, cooled to the mashing temperature (near 140°F.) and saccharified. In this process the starch is converted to sugar, usually by the action of malt, for the reason that yeasts by themselves are unable to ferment starch. The malt commonly used is germinated barley which contains the enzyme, diastase, by means of which the saccharification is accomplished. A yeast suspension is then added to the saccharified mash and the fermentation allowed to proceed until the starch is completely converted into alcohol, which is then removed and purified by distillation. The concentrated slop or waste resulting from the fermentation of the cereal grains may be used for feed. When dried, it is known as distillers' dried grains. It is rich in protein and has a high feeding value, particularly when the germ has not been removed.

CORN UTILIZATION RESEARCH

The establishment of four regional laboratories for research on the utilization of farm products and byproducts was authorized by Section 202 of the Agricultural Adjustment Act of 1938. Under this section the Secretary of Agriculture was authorized and directed to "establish, equip, and maintain four Regional Research Laboratories, one in each major farm producing area, and, at such laboratories to conduct researches into and to develop new scientific, chemical, and technical uses and new and extended markets and outlets for farm commodities and products and byproducts thereof. Such research and development shall be devoted primarily to those farm commodities in which there are regular or seasonal surpluses, and their products and byproducts." These Laboratories are located at Peoria, Illinois; New Orleans, Louisiana;

Albany, California; and Wyndmoor, near Philadelphia, Pennsylvania. To the Laboratory at Peoria, known as the Northern Regional Research Laboratory, have been assigned the researches for discovering and developing new uses for corn, wheat, and agricultural residues.

The researches being conducted on corn include determination of composition and structure of different varieties produced under various environmental conditions; investigations dealing with the production, modification, and utilization of the starch, oil, and protein constituents of the kernel; and investigation of the derivation and utilization of alcohol, sugar, zein, and other products from the constituent parts of the corn kernel. The work of conducting these researches will be carried on through the following Divisions: Agricultural Motor Fuels Division, Agricultural Residues Division, Analytical and Physical Chemical Division, Commodity Development Division, Engineering and Development Division, Fermentation Division, Oil and Protein Division, and Starch and Dextrose Division.

The equipment of the Northern Regional Research Laboratory includes, besides the necessary apparatus and facilities for making chemical and physical tests, a pilot plant for testing on a semi-commercial scale of production, the new processes or products developed in the laboratory.

